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(71) Applicant(s)
Jennifer Annette Bellairs

(72) Inventor(s)
Peter Bellairs

(74) Agent/Attorney
Cullen and Co,GPO Box 1074,BRISBANE QLD 4001

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ABSTRACT

A method of opencut blasting in ground having a temperature of less than 55°C wherein said method comprises the steps of charging a blasthole with an explosive charge, priming said explosive charge with at least one primer disposed within the explosive charge wherein the at least one primer includes a main primer disposed within a top portion of explosive charge, and detonating said explosive charge with an initiation sequence in which the main primer is the first of the at least one primer initiated wherein the peak particle velocity resulting from the detonation of the explosive charge 300 metres from the blasthole is greater than 4mm/sec.

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COMPLETE SPECIFICATION
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Name of Applicant: Jennifer Annette Bellairs

Actual Inventor: Peter Bellairs

Address for Service: CULLEN & CO
Patent & Trade Mark Attorneys,
239 George Street
Brisbane Qld 4000
Australian

Invention Title: A Method of Blasting

The following statement is a full description of this invention, including the best method of performing it, known to us:

FIELD OF THE INVENTION

The present invention relates to a method of blasting. In particular the present invention relates to a method of blasting in opencut applications.

BACKGROUND ART

In most blasting applications in opencut mines at normal ground temperatures bulk explosive are charged into a blasthole and primed using a main primer positioned near the bottom of the hole. It is believed that the main primer should be placed near the bottom of the blasthole with the detonation of the bulk explosive progressing up the blasthole to the surface. Priming the bulk explosive near the bottom of the blasthole maximises the confinement of the detonation. Some degree of confinement is generally required in order to detonate the bulk explosive and a high degree of confinement is required to get the most work out of the bulk explosive. A high degree of confinement assists the bulk explosive to reach full order detonation where the maximum energy release occurs.

In addition it is believed that by detonating the bulk explosive using a primer positioned near the bottom of the blasthole the explosive gases are kept from venting to the atmosphere. In this way the highest pressure is maintained for an extended period to ensure that the rockmass is moved and additional breakage occurs with maximum efficiency. It is also conventional wisdom that by detonating the bulk explosive using a primer positioned near the bottom of the blasthole better breakage is achieved at bench floor level and the base of the blasthole.

Additional primers may be used in deep blasthole to ensure reliable detonation of all of the bulk explosive. Generally primers are positioned at 10 to 15 metre vertical intervals up the explosive column to overcome the effects of ground shift, a failure of the primer to detonate such as by damage to the downline, manufacturing faults in either the downline, the detonator or the booster, or the primer being inadvertently positioned in explosive that fails to detonate.

There are a limited number of applications where the bulk explosive is detonated using a primer positioned at the top of the blasthole.

These applications are where the ground is at an elevated temperature. In so-called "hot holes" a primer may be positioned at, or near, the top of the bulk explosive. "Hot-holes" are holes where the ground temperature is in excess of 55°C. The detonation sensitive primers are positioned at the top of the blasthole where the ground temperature is the coolest so as to minimise the risk of accidental detonation. There are also applications where blast performance is sacrificed in an attempt to reduce or attenuate blast-induced vibrations. As one component of a multi-component vibration reduction strategy, a primer has been fired from a top portion of a blasthole with other vibration reduction or attenuation measures. Such multi-component strategies have been employed in blastholes that are located in areas where there are structures, such as houses, that may be adversely affected by blast induced ground vibration. Blast induced ground vibration that is likely to adversely affect such structures is generally considered to be blasts having a peak particle velocity of greater than 5mm/s. A variety of field controls and blast design criteria are employed to ensure that the peak particle velocity is maintained below 5mm/s. This may be achieved for example by ensuring that a maximum instantaneous charge (MIC) is met. The MIC is the largest charge detonating at one time that will generate a blast-induced vibration below the selected level. The timing design factors ensure that only a MIC is detonated for each delay. The blast design ensures that the MIC is met while the field controls ensure that the bulk explosive is loaded accurately up to the MIC. Subdrill (the portion of the blasthole below the level to be excavated) is minimised as the rock surrounding this will not move and generates significant vibration. Field controls also minimise variation in designed burdens and spacings to ensure that these are not too large therefore impeding forward movement and increasing jarring ie vibrations. The maximum size of each blast is controlled to minimise delay overlap as well as to stop the blast from choking (after 4 or 5 rows the delays are not long enough for the rock to be moving in front of the detonating blastholes). As subsequent blastholes detonate, the rock has no place to move and the jarring and vibration effect is increased. Most of the above techniques are used in combination to reduce or attenuate vibration.

It is conventional wisdom in the art that bottom priming is essential in order to achieve optimal blast performance. It is believed that it is essential to position the primer at or near the grade or bench (the bottom of the blasthole). This is because it is believed that the positioning of the primer at the base of the blasthole ensures the minimum run up so that the explosive quickly achieves the maximum shock energy produced at steady state detonation. In addition the conventional wisdom requires the confinement theoretically achieved by initiating the explosive at the base of the blasthole.

We have now found that by positioning the main primer at the top of the explosive charge a number of significant advantages may be obtained.

SUMMARY OF THE INVENTION

In one broad form, the present invention provides a method of opencut blasting in ground having a temperature of less than 55°C wherein said method comprises the steps of charging a blasthole with an explosive charge, priming said explosive charge with at least one primer disposed within the explosive charge wherein the at least one primer includes a main primer disposed within a top portion of explosive charge, and detonating said explosive charge with an initiation sequence in which the main primer is the first of the at least one primer initiated wherein the peak particle velocity resulting from the detonation of the explosive charge 300 metres from the blasthole is greater than 4mm/sec.

We have found that by positioning the main primer at the top of the explosive charge there are a number of advantages to be gained over the conventional positioning of the primer at the bottom of the explosive charge. These advantages include an ability to reliably employ emulsion cartridges instead of cast boosters. We have also found that the positioning the main primer at the top of the explosive charge may provide reductions in both drilling costs and blasting costs as well as a reduction in unit mining costs.

The method of blasting of the present invention is applicable to opencut mining. The blasting techniques used in opencut mines vary from those used in underground applications. Opencut blasting is a technique used for blasting in mining applications where the mine is of the opencut type.

Opencut mines are excavations for removing minerals that are open to the weather. Such mining methods may include the steps of removing the overlying overburden or waste and, extracting the targeted mineral or commodity. The removal of the overburden or waste and the breaking up of the targeted mineral or commodity generally requires the use of explosives. The overburden or waste may be replaced and the opencut mine site remediated. Opencut mines are alternatively known by, or include in their general type, a variety of other terms used to describe a mine structure or technique. Such terms include opencast mines and quarries. These types of mines may have a number of benches or generally horizontal floors along which the overburden or waste, or targeted mineral is worked or quarried.

The blasting method of the present invention is applicable to such opencut mines where the ground temperature is less than 55°C. In ground temperatures of greater than 55°C specialized blasting techniques are employed and such specialized techniques are considered uneconomic for general use in opencut applications. Whilst blasting techniques have been known to be employ a version of top priming in so-called "hot holes" where the ground temperature is greater than 55°C, such techniques generally employ top priming in combination with other blasting techniques.

Peak particle velocity is a measure of the ground vibration. The method of the present invention is applicable where ground vibration is not of significant concern and the peak particle velocity resulting from the detonation may exceed 4mm/sec 300m from the blasthole. The method of the present invention preferably provides a peak particle velocity in excess of 6mm/sec 300m from the blasthole and more preferably a peak particle velocity in excess of 8mm/sec 300m from the blasthole. The method of the present invention in another embodiment preferably provides a peak particle velocity in excess of 4mm/sec 400m from the blasthole and more preferably 500m from the blasthole.

The method of the present invention includes the step of charging the blasthole with an explosive charge. The blasthole may be charged with explosive using conventional techniques. For example a bulk explosive may be manufactured in a mobile mixing unit (MMU) at the top of

the blasthole and delivered into the blasthole using a suitable auger or pumping unit. Of course other methods of charging the blasthole may be employed. For example the bulk explosive may be manufactured at a central facility and then be transported to the blast site for charging into the blasthole. Packaged explosives may be loaded into a blasthole by convenient means.

The method of the present invention may be used to detonate any suitable explosive charge. Explosive charges may be in a variety of forms such as either bulk explosives or packaged explosives. Bulk explosives may be in liquid form, solid form, particulate form, emulsion form or combinations thereof. Generally explosives are based on the combination of an oxidiser salt and a fuel and are in emulsion or particulate form. Emulsion explosives typically are in the form of a water-in-oil emulsion or oil-in-water emulsion (watergel). An aqueous solution of oxidiser salt forms the discontinuous phase and fuel oil forms the continuous phase in water-in-oil emulsions and vice versa for oil-in-water emulsions. Emulsifying agents, gelling agents and thickeners are typically used to assist in the formation and stabilisation of the various emulsion types. Other adjuvants may be used to modify the properties of the emulsion. For example, gas bubbles or hollow particles may be used to sensitise the emulsion, additional fuels such as aluminium particles may be used to increase the explosive energy of the emulsion, and prilled ammonium nitrate or ANFO (Ammonium Nitrate – Fuel Oil) may be used to increase the heave energy of the emulsion.

Particulate bulk explosives, such as ANFO based explosives are also used as explosive charges. ANFO based explosives are formed from prilled ammonium nitrate at about 94% by weight blended with 6% fuel oil.

These types of bulk explosives can be detuned by adding diluents such as sawdust, polystyrene, rice husks etc for blasting in soft or well jointed easy to blast ground. These rock types do not need full strength explosives so explosive costs are reduced by replacing some of the explosive with low cost material that is correctly mixed with the explosive to ensure a stable detonation.

The present invention also contemplates the use of packaged explosives to form the explosive charged into the blasthole. Bulk explosives

of types referred to above as well as other suitable bulk explosives may be used in the method of the present invention.

Explosive charges generally need to be primed in order to be efficiently detonated. Explosive charges are not generally cap-sensitive and are not detonable with a simple detonator. Typically a primer, a booster with a detonator inserted therein, is used whereby the primer initiates the bulk explosive. Detonators are connected to an initiation system. Detonators may be electric or electronic and connected to an electric or electronic initiation system by wires. Alternatively, and more commonly, detonators may be of the non-electric type and initiated by shock tube. In another initiation system, detonating cord may be used whereby the need for a separate detonator is eliminated whereby the detonating cord initiates the primer directly. A network of transmission means may be layed out around the surface of a blast site that incorporates a number of blastholes.

Downlines extend from the surface of the blast site down into the blastholes to the primers. At the bottom of a downline is a detonator that is attached to the downline. Detonators are inserted into boosters that are high-energy explosives. At the surface the top end of the downline is attached to a surface line that also has a detonator that is attached to the downline. The initiation system is really a communication system that enables a signal/impulse to go from the surface system to the downline, then the downline to the detonator that explodes and detonates the booster that detonates the explosive charge. The detonators may incorporate a delay for controlling the time from receiving the signal to detonating. Through the appropriate use of delays the time for each blasthole to detonate can be controlled to ensure an efficient blasting sequence in an array of blastholes.

Downlines may be formed from a variety of transmission media. Shocktubes may be used. Shocktubes are hollow plastic tubes that have an inside layer with an electrostatic charge that retains a thin coating of explosive dust. Shocktubes operate by transmitting a detonation within the hollow tube. As the detonation is transmitted along the shock tube, explosive dust is displaced from the inner surface of the tube a small distance in front of the detonation forming a cloud of dust that detonates displacing more explosive

dust ahead of the detonation. In this way the detonation moves down the downline to the detonator initiating the detonator. Shocktube comes in two types – standard & heavy duty (HD). The standard tube is currently rated to about 35m depth & about two weeks sleep time (sleep time is the length of time that the downline can be in explosive before its reliability – ability to detonate – starts to be compromised). Standard tube is cheaper than HD tube by about 30% per metre. The HD tube is either thicker &/or composed of different plastic that makes it more abrasion, oil resistant and stronger than standard tube and thus can sleep for extended times &/or be used in deeper blastholes or more abrasive aggressive conditions than standard tubes.

The present invention renders at least the longest downline in the blasthole unnecessary or shortening the length of downline used in a singly primed blasthole. This may also permit the use of standard tube in applications typically requiring the used of heavy-duty tube. Even in the more aggressive conditions the top primed downline could be replaced with standard tube. The invention permits the use of standard tube to be used and significantly less heavy-duty tube to be utilised creating substantial savings.

Detonating cord consists of a core of PETN, a molecular explosive, that is protected by a number of layers of various material types to provide strength, abrasion resistance, water resistance and good handling characteristics. The core load of PETN is variable from about 1 – 70 g/m but for downline use is normally in the range from 1 – 5 g/m. A detonator is generally not required at the end of a detonating cord downline as the detonating cord generally has sufficient energy to initiate a cast booster or packaged emulsion boosters.

Electronic blasting systems (EBS) generally use a suitable electrical wire/cable system for the downline although one variant uses shocktube. The standard EBS uses electrical impulses to both program and to detonate the detonator whilst the shocktube variant uses pre – programmed detonators and the shocktube detonation provides the impulse to fire the detonator at the programmed time.

Boosters for use in the method of the present invention may be

of any convenient type and may be in the form of a cast booster. However the present invention is advantageous in that the use of emulsion cartridges is permitted.

Cast boosters are generally considered the best means to initiate a column of bulk explosive. Cast boosters provide high detonation pressures and high detonation temperatures that lead to more reliable initiation of the explosive charge. This is particularly the case in current blasting practises where, at the base of the blasthole, the explosive charge is often contaminated by the dust or sludge that exists at the base of the blasthole prior to loading the explosive charge. Furthermore the use of cast boosters has been preferred when positioned at the base of a column of explosive charge as they provide extra energy to break the rock at bench level. Cast boosters also provide lower run up distances thereby generating more energy out of the explosive charge. Run up distance is the distance it takes from the detonating primer for the explosive to reach full order steady state detonation (where the explosive charge is releasing the maximum amount of overall energy).

Cast boosters are generally made of a mixture of two molecular explosives that are cast into cylinders weighing 150 – 175g to 400- 450g usually. In most opencut applications the larger booster size is used. These boosters/primers have very high detonation pressures in the region of 21 - 24GPa and high detonation temperatures of about 5000 - 6000°C. Typically, in explosive charges primed at their base large (400-450g)cast boosters are used to minimise the risk of a failure to initiate the explosive charge in blastholes over 102mm in diameter with smaller cast boosters being used in the smaller diameter blastholes.

Generally other boosters/primers such as emulsion cartridges are only used in specialised applications where full order detonation is not required. We have found that emulsion cartridges function particularly well in the blasting method of the present invention.

Emulsion cartridges are made of emulsion that detonates providing somewhat lower pressures and temperatures than cast boosters (6 – 8 GPa, 4000 – 5000°C). Whilst these pressures and temperatures are

lower than those of cast primers they are nevertheless sufficient to reliably initiate explosive charges. Emulsion cartridges are significantly cheaper than cast primers, being about 50% of the cast booster price for a 500g cartridge. Whilst the run up distance is slightly larger in the method of the present invention this provides a further advantage in that additional heave energy is produced in the explosive run up region and this translates to improved digging and cast. In bottom-primed methods any extra heave generated in the subdrill region is of no substantial benefit.

The primer/booster in the vast majority of blasting only forms a small fraction of the overall explosive charge (generally less than 1%) and even in gold mining using small bench heights and small explosive charges (15 – 25kg per hole) the booster makes up about 2 – 3%. Whilst the higher detonation pressure and temperature of a cast primer does enable the explosive charge to reach steady state detonation slightly quicker, this may not in all conditions produce optimal blast outcomes. In the vast majority of rock types in Australia and in the Americas the extra heave energy generated at the top of the blasthole by the use of a cartridged emulsion in the method of the present invention produces better blast outcomes in the form of easier to dig blasts.

At least one primer is disposed within the explosive charge located in the blasthole. The at least one primer includes a main primer that is disposed within a top portion of explosive charge. The explosive charge is detonated with an initiation sequence in which the main primer is the first of the at least one primer initiated.

The main primer is disposed within a top portion of the blasthole. Preferably the top portion of the blasthole extends down up to 25% of the depth of the blasthole charged with explosive charge. However, it is believed that the main primer can be located in any portion of the explosive column from the around the mid point of the explosive charge up. It is preferred that the main primer be disposed within the explosive charge to a depth equivalent to at least 4 – 6 blasthole diameters below the stemming/explosive interface.

Stemming material may be placed on top of the explosive

charge within the blasthole. Stemming material is inert material such as rock, often in the form of drill chips excavated from the blasthole or crushed angular aggregate, that is used to cap the explosive charge and confine, to an extent, the initiated explosive charge.

In certain applications the blasthole may be charged with a number of separate explosive charges. In the context of the present invention each deck of explosive may be initiated in accordance with the present invention whereby each deck includes a main primer that is disposed in the top portion of each deck of explosive charge.

The method of the present invention permits a blasthole to be reliably primed with a single primer, the main primer disposed in the top portion of the explosive charge. The removal of the need for one of the backup primers and associated downlines is possible in accordance with the present invention as it is believed that there is less likely to be ground shift in the basal portions of deep blastholes. Without wishing to be bound by theory, it is believed that this is due to the additional confinement in the rock mass with increasing depth. The use of a single primer positioned in the top portion of the explosive charge makes the recovery of a primer easier in misfired situations such as the failure of the initiation system. When compared to bottom primed blastholes the downline is more likely to be intact and less material needs to be removed from the hole to expose the primer.

It is within the scope of the present invention that at least one primer be used. Primers additional to the main primer may be used to provide a backup initiation system should the main primer fail to detonate the bulk explosive either through a failure of the bulk explosive or of the initiation system.

Generally, it is preferred that for each 10 – 15m of explosive charge in the blasthole another downline and primer be used. Thus for a 50m deep blasthole there would preferably be three downlines and primers substantially spaced in the explosive charge. The present invention permits the longest downline assembly in a multi-primed blasthole to be omitted.

The initiation system acts to detonate the main primer first and subsequently, in a preferred embodiment, acts to detonate the further primers

in order of increasing depth.

Conventional blasting techniques generally ignore the contamination of explosive at the bottom of the hole as well as over emphasising confinement of explosive gases. Without wishing to be bound by theory we believe that explosive gases only need to be confined as long as it takes for the rockmass to start to move because once the movement commences the gas pressure drops dramatically. In the process of the present invention we have found that by positioning the main primer in the top portion of the explosive charge it is not only possible to reliably and economically conduct blasts, but that significant and unexpected advantages in the blasting process and outcomes may be obtained. In order that the advantages of the present invention may be fully appreciated a number of the advantages will be described with reference to particular blasting applications. However, the advantages of the present invention may generally be said to include increased coal standoff distance due to improved fragmentation at the base of each blastholeis believed to result from the detonation being driven into the base of the hole increasing fragmentation at the base of the blasthole. These advantages result in optimised blast performance and corresponding savings in drilling and explosives. The present invention also provides a reduced subdrill (blasthole distance below the new bench) also resulting in significant savings.

In addition the present invention provides reduced initiation costs due to a reduction in downline and primers in longer blastholes or reduced downline length in shorter blastholes. Furthermore, as a result of the reduced downline length standard shocktubes rather than HD shocktubes may be used. Emulsion primers may also be used to reliably initiate the explosive charge.

Increased cast in mines such as coal mines means that additional material is moved into its desired location without having to be moved by a dragline. The present invention may result in improved dig rates for both dragline and shovel/excavator due to looser easier to dig blasts.

Pattern expansion may also be provided by the use of the method of the present invention. Slightly wider spaced blastholes may be

used thereby reducing dill and blast costs whilst still achieving similar blast results to that achieved using bottom priming.

Blastcrew time may be reduced by the use of less downlines and also shorter downlines.

Improved lump:fine ratio may be provided in mines such as iron ore mines due to reduced subdrill pre-conditioning at the top of next bench and the reduced shock energy in the bench being dug. Due to the large price differential between lump and fines this is a significant advantage of the present invention.

Electronic blasting systems may also be used in conjunction with the process of the present invention for the majority (>50%) of blasting applications due to reduced downline lengths. Current EBS technology does not tolerate deep hole (>20m) conditions well experiencing unacceptable failure rates as the thin wire downlines are easily damaged. The shorter downline length enabled by the current invention means that deeper blastholes than at present can utilise the considerable advantages of EBS.

<u>Coal Mines</u>

The main advantages of the process of the present invention are increased coal stand off, reduction in downlines & primers &/or reduced downline length, change in downline type and change in primer type, reduced vibration, increased cast, improved dig rates, pattern expansion and reduced blastcrew time.

Increased Standoff

Blastholes are not generally drilled to the top of coal body, except every 7 – tenth blasthole to monitor the top of coal deviation from plan so as to adjust blasthole length to the actual top of coal. If blastholes were routinely drilled to top of coal and beyond then a substantial amount of the coal would be damaged due to the high detonation pressures of the explosives in the overburden. As the coal is softer than most of the overburden material the explosive energy would preferentially migrate from the harder overburden to the coal further increasing the blast-induced

damage to the coal. Such damage results in coal fines generation plus creating soft damaged portions at the top of the coal seam. The digging equipment removing the overburden then tends to scoop these soft areas of coal out with the coal disappearing into the spoil (waste). It is for this reason that the base of the blasthole is generally maintained some distance from the top of coal. Blasting too close to the top of the coal body may also result in the production of coal fines and result in lost coal production with the fines being discharged as part of the tails if the coal is washed. The distance of the blasthole from the top of the coal body is called the standoff distance and is affected by the type of overburden immediately above the coal and the coal type eg hard overburden and harder coal require shorter stand off distances whilst softer overburden and softer coal permit greater stand off distances.

The method of the present invention provides increased coal standoff distance. Whilst not wishing to be bound by theory, the increased standoff distance is believed to be due to improved fragmentation at the base of each blasthole due to the primer being out of contaminated explosive and the detonation being driven into the base of the hole increasing fragmentation.

Without wishing to be bound by theory, it is believed that bottom priming does not generate steady state detonation in the region adjacent the base of the blasthole and hence the velocity of Detonation (VOD) tends to be lower than throughout the rest of the explosive column. This is especially so if a portion of the bulk explosive is contaminated with material from the bottom of the blasthole. Both of these factors tend to mean that standoff distances are reduced. By top priming in accordance with the present invention the VOD is at maximum as it reaches the basal explosive, the detonation is travelling towards the bottom of the hole reinforcing the shattering effect, and the effect of contaminated explosive is reduced.

Reduction in downlines & primers &/or reduced downline length, change in downline type and change in primer type

A direct consequence of setting the main primer in the top of the blasthole is the reduction in the length and specification of the downline. We

have also found that the primer used may be of lesser strength. In blastholes where a cast primer would typically be specified in a bottom primed charge we have found that a cartridged emulsion booster is sufficient to detonate the bulk explosive in many applications. In the example of the 50m deep blasthole where three downlines & primers are used in bottom priming only two are required with top priming. In addition the two downlines required can be changed to standard tubes from the generally required HD tube.

Reduced Vibration

Top priming has been used in underground applications in conjunction with other vibration reduction and attenuate techniques. We have found that the process of the present invention also reduces vibration in opencut applications to a significant degree without additional vibration or attenuation strategies. We have found that as a result of the other advantages in employing the process of the present invention such as reduced subdrill and less overall explosive charge being required to achieve the desired blast performance (pattern expansion and increased standoff).

Increased Cast

We have found that the process of the present invention provides slightly higher cast, particularly when used with a cartridges emulsion booster as the main primer. Without wishing to be bound by theory, we believe that the higher cast is provided as a result of the top of the rockmass moving first whilst the additional run up distance associated with the use of cartridged emulsion primers will result in more gas energy at the top of the shot which combine to increase cast in this area. We have found that the bottom of the rock mass being blasted is anchored in place by the rockmass itself or a buffer of broken material may be conveniently placed at the front base of the shot to stop coal and coal edge movement.

Improved Dig Rates

We have also found that both shovel (excavator) and dragline dig rates should improve due to the extra looseness generated in the priming

area. In shovel blasting the dig rates will also improve based on the improved fragmentation in the bench floor area.

Pattern Expansion

We have found that as a result of the improved blasting performance blastholes may be spaced further apart with the retention of blast performance. Typically we have found that the space between the blastholes may be increased in the region of 0.25 – 0.5m by employing the process of the present invention. This enables traditional dig rates to be achieved with savings being generated by reductions in drilling, bulk explosive, initiation and blastcrew time.

Reduction in Blastcrew time

The elimination of downlines and boosters and/or the reduction in downline lengths lead to reduced blastcrew time in both getting material from the magazines, placing the downlines in the hole as well as the reduced time in pulling bottom primed downlines up in wet holes.

Iron Ore Mines

In iron ore mines the process of the present invention may be employed to provide a number of advantages in the blast performance. These improvements include reduced subdrill, improved dig rates, reduced vibration and consequent improvement in the final walls, reduced blasthole initiation cost, reduced blastcrew costs, higher lump: fine ratio, and reductions in ultrafines.

Reduced Subdrill

The process of the present invention allows a blast to be conducted with reduced subdrill. The reduced subdrill provides advantages in both face shovel and excavator type blast designs. We have found that the damage angle obtained after initiation of a blasthole using a primer located in the top portion of the explosive charge is flatter than that obtained with bottom priming techniques. Thus we have found that in the process of the present

invention the subdrill can be reduced to obtain the desired bench level for any well designed blasthole spacing.

Generally to dig a new bench floor blastholes must be drilled below the desired benchfloor such that when the bulk explosive detonates it creates a damage envelope around the blasthole the angle of which is determined by the rock type and the explosive type and efficiency. The aim is to have the damage envelopes meeting at the mid point at the new bench floor level between adjacent holes. If they meet above the new bench floor the floor will not be able to be dug to the correct level and equipment damage will result (digger, truck etc) and production will be adversely affected. If the damage envelopes meet below the new bench floor wasted energy, uneven floors and digging below the desired benchfloor occurs. We have found that by employing the process of the present invention reduced subdrill is required with savings in both drilling and explosive costs.

Improved dig rates

Improved dig rates may be provided in a manner similar to that described with reference to coal mining.

Reduced Vibration – Final Walls

Reduced vibrations may be provided in a manner similar to that described with reference to coal mining. The combination of reduced vibration and reduced subdrill lead to reduced blast induced ground vibration that positively impacts on final wall stability.

Reduced Blasthole Initiation Cost

Several of the rock types present in iron ore mines are abrasive and this together with the large scale stemming gear generally requires the use of HD downlines. However, by employing the process of the present invention standard shocktube downlines may be used to initiate the main primer. In addition, the safety primers disposed further down the blasthole but also in the top portion of the blasthole may utilise standard shocktube. In addition reduce downline length is required. For a 15m bench height the

downline length is 18 – 20m to ensure that there is enough length to account for the large pile of drill chips on the surface. With the process of the present invention this can be reduced to 12 – 14m which represents a significant saving. The saving is even greater in applications where a doubledet booster (cast booster having two detonator wells requiring two downlines to be used). Savings will also occur with the use of cartridged emulsion primers and with electronic blasthole initiation systems.

Reduced Blastcrew Costs

The reduction in downline lengths lead to reduced blastcrew time in both getting material from the magazines, placing the downlines in the hole as well as the reduced time in pulling bottom primed downlines up in wet holes.

Higher Lump: Fine Ratio

Lump iron ore is generally considered to be material greater than 8.4mm in diameter. Anything that is smaller than this is sold as fines and is of lesser value. It is therefore desirable to maximise the amount of lump iron ore produced. The present invention, particularly when combined with the use of cartridged emulsion primers provides an improvement in lump:fine ratio. This with the reduced subdrill will assist as there is less blast damage to the top of the next bench that translates into improved lump production.

With the use of cartridged emulsion primers and the consequent additional run up distance will also provide a reduction of shock energy thereby reducing the generation of fines and producing greater lump.

Reduction in Ultrafines (-63 micron)

The mechanisms as described above also lead to a reduced volume of the crushed (pulverised) zone surrounding the detonating blasthole charge via the reduced charge length blasthole which in turn potentially results in a reduction in the ultrafines being generated. Ultrafines are important as they impact deleteriously on iron ore producers. Excessive ultrafines contribute to a fines-in-lump problem by readily sticking to damp

lump. Customers generally specify a maximum amount of ultrafines that are permitted before the value of the lump iron ore is reduced.

The ultrafines also attract moisture potentially leading to moisture penalties being imposed for both lump and fine ore leading to reduced product price and potential sales losses. Ultrafines in material that is processed through beneficiation are simply discharged to waste thereby resulting in lost saleable product.

GOLD MINING (< 8m Bench Height)

In gold mining the main advantages that are able to be derived by the use of the present invention include reduced subdrill, reduced down hole initiation costs, reduced blastcrew costs, improved dig rates, pattern expansion, reduced vibration and reduced dilution.

The reduced dilution is achieved especially in the bottom flitch due to the higher shock energy available and the reduced heave energy. The reduced subdrill will also reduce dilution in the top flitch of the next bench as there will be less disturbance of the rockmass. Whilst the process of the present invention may increase movement in the top flitch this is of less concern as this movement is likely to be monitored and therefore known and appropriate techniques used to minimise any adverse impact. The monitoring of the bottom flitch is less likely and thus any additional heave in this area may result in additional dilution.

METALLIFEROUS MINING (Includes > 8m Bench Height Gold Mines)

In metalliferous mining the main advantages that are able to be derived by the use of the present invention include reduced subdrill, reduced vibration, reduced blastcrew costs, reduced down hole initiation costs, improved dig rates, pattern expansion and reduced dilution.

QUARRYING

In quarrying the main advantages that are able to be derived by the use of the present invention include reduced subdrill, reduced vibration, reduced blastcrew costs, reduced down hole initiation costs, improved cast

and improved dig rates.

Quarry operators will generally utilise the increased dig rates rather than pattern expansion as this will either translate into being able to produce the same amount in less time leading to reductions in operating costs or produce more in the same time frame resulting in reduced unit costs. The improved cast may not be a concern as quarries use small mobile FEL 's as their main digging gear. The looser muckpile created will enable improved dig rates.

ELECTRONIC BLASTING

The process of the present invention is particularly suited to the use of electronic blasting. This relatively new initiation system holds exciting promises based on initial results but is suffering from a number of technical issues. One of these technical issues is the ability for the blasthole portion of the system to survive in blastholes deeper than 20m. The process of the present invention will enable electronic blasting to be utilised in the majority of blasting applications thereby making this system and all its advantages available.

In order that the invention may be more fully understood and put into practice, preferred embodiments thereof will now be described with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a schematic representation of a blast configuration in accordance with one aspect of the present invention.

Figure 2 shows a blast configuration in accordance with a second aspect of the present invention.

Figure 1 shows a bench 1 having a series of blastholes 4 drilled therein. The blastholes 4 are drilled to a depth so as to enable the formation of a new bench having a top at the floor 3. The blastholes 4 extend below the floor 3 to the depth of the subdrill 5.

The blastholes 4 are charged with explosive 6. Explosive 6 is primed with primer 7 that is connected to an interconnecting initiation system 9 by downline 8. Stemming material 10 is packed on top of the explosive

charge 6 to aid in the confinement of the detonation and prevent unhindered air blasts.

Figure 2 shows a multi deck blast configuration in which each blasthole 4 has three decks of explosive charges 12, 17 and 23 respectively.

At the base of each blasthole 4 there is a base deck of explosive charge 23. The base deck of explosive charge 23 is primed with primer 24. The primer 24 is connected to a third interconnected initiation system 27 by a third downline 25. Disposed above the base deck of explosive charge 23 is a second decking material that may be in the form of an air gap formed from an inflatable bag or other means for separating the respective explosive charges.

An intermediate deck of explosive charge 17 is disposed above the second deck 26. The intermediate deck of explosive charge 17 is primed with primer 17a that is connected to a second initiation system 20 by a second downline 19.

Above the intermediate explosive charge 17a there is a first decking material. The first decking material may be an inflatable bag of the type described below or other decking material as will be known to those skilled in the art.

Above the first decking material 20 is a top deck of explosive charge 12. The top deck of explosive charge 12 is primed by primer 13. Primer 13 is connected to a first interconnected initiation system 15 by a first downline 14. The top deck of explosive charge 12 is covered by stemming material 10a.

Persons skilled in the art will appreciate that the invention described above may be subject to improvements and modifications that will be apparent without departing from the spirit and scope of the invention described herein.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of opencut blasting in ground having a temperature of less than 55°C wherein said method comprises the steps of charging a blasthole with an explosive charge, priming said explosive charge with at least one primer disposed within the explosive charge wherein the at least one primer includes a main primer disposed within a top portion of explosive charge, and detonating said explosive charge with an initiation sequence in which the main primer is the first of the at least one primer initiated wherein the peak particle velocity resulting from the detonation of the explosive charge 300 metres from the blasthole is greater than 4mm/sec.

2. A method according to claim 1 where in the peak particle velocity resulting from the detonation of the explosive charge 300m from the blasthole is greater than 6mm/sec.

3. A method according to either claim 1 or claim 2 where in the peak particle velocity resulting from the detonation of the explosive charge 300m from the blasthole is greater than 8mm/sec.

4. A method according to any one of claims 1 to 3 wherein the peak particle velocity is in excess of 4mm/sec when measured 400m from the blasthole.

5. A method according to any one of claims 1 to 3 wherein the peak particle velocity is in excess of 4mm/sec when measured 500m from the blasthole.

6. A method according to any one of claims 1 to 5 wherein the explosive charge is a bulk explosive selected from the group consisting of water in oil emulsions, water gels and ANFO based explosives.

7. A method of blasting according to any one of claims 1 to 5 wherein the explosive charge is formed from packaged explosives.

8. A method of blasting according to any one of claims 1 to 7 wherein the primer is formed from a cast booster.

9. A method of blasting according to any one of claims 1 to 7 wherein the primer is formed from an emulsion cartridge.

10. A method of blasting according to any one of claims 1 to 9 wherein the main primer is disposed within the top 25% of the depth of the

explosive charge.

11. A method of blasting according to any one of claims 1 to 9 wherein the main primer is disposed within the explosive charge to a depth equivalent to at least 4 blasthole diameters below the top surface of the explosive charge.

12. A method of blasting according to any one of claims 1 to 11 wherein stemming material is disposed on top of the explosive charge.

13. A method of blasting according to any one of claims 1 to 12 wherein the blasthole is filled with a plurality of decks of explosive charge wherein the main primer in respect of each deck of explosive charge is disposed within the top portion of said deck of explosive charge.

14. A method of blasting according to any one of claims 1 to 13 wherein additional primers are disposed within the explosive charge.

15. A method of blasting substantially as hereinabove described with reference to the accompanying drawings.

DATED this 28th day of March 2002
Jennifer Annette Bellairs
By her Patent Attorneys
CULLEN & CO.

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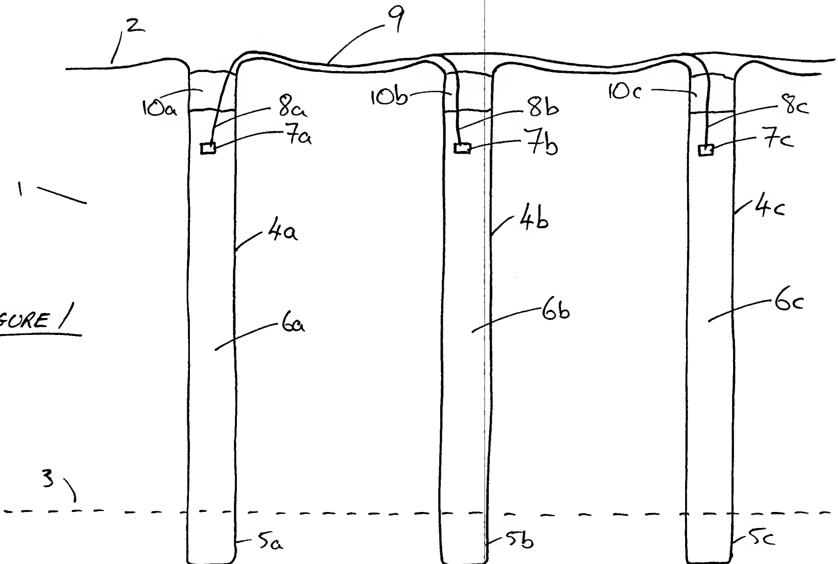

FIGURE 1

20 3 02 29199

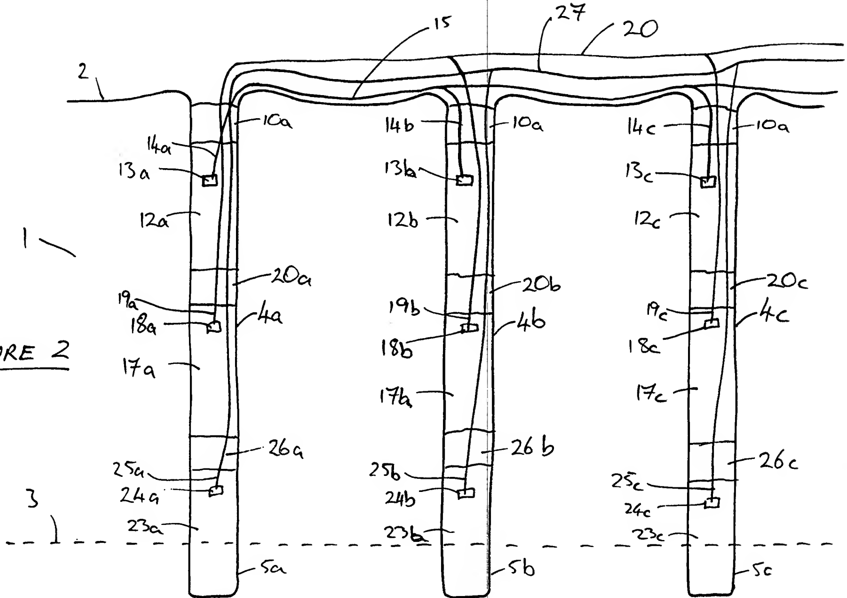

FIGURE 2